STRATEGIC BEHAVIOR IN THE CRUDE OIL MARKET: ONE-STAGE VS. TWO-STAGE OLIGOPOLY MODELS

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Overview

The complexity of the crude oil market makes it one of the resource markets the most difficult to grasp. On the one hand it has been empirically shown that the market is driven by fundamentals and that speculation affects the market only at the margin reinforcing fundamental tendencies (see Hamilton, 2009 and Kaufmann, 2011). Thus it would be theoretically possible to build a partial equilibrium model of the crude oil market.

However, the crude oil market is characterized by a few dominant players that possibly behave as a cartel (OPEC) and smaller players (IOCs) that we can assume to be competitive fringe suppliers. The role of OPEC has been intensively and controversely discussed in the literature. For example Böckem (2004) using New Empirical Industial Organization finds that OPEC behaves as a price leader while Lin (2009) using a Hotelling model rejected the behavior as a cartel for the last twenty years.

This paper uses a partial equilibrium approach to try to answer the question of the market structure of the crude oil market. The difficulty here is to find a correct market structural representation of the various players involved. This paper reviews the possible models that could be used starting with standard one-stage oligopoly models such as the Cournot models and conjectural variations model. We then review and extend two-stage models in order to obtain a more realistic representation of a dominant oligopoly with a competitive fringe. The dominant oligopoly can be a strict cartel, a Cournot-oligopoly or behave in a Nash-bargaining competition. The different market structure models are then implemented numerically and compared with real market data of the global crude oil market for the years 2000 to 2010

Methods

We use partial equilibrium modeling techniques that have been widely used to model resource markets such as the natural gas market (Boots et al. 2004, Egging et al. 2008) or electricity markets (Hobbs, 2001).

Haftendorn (2012) shows that using one-stage oligopoly models based on the conjectural variations approach can lead to counter-intuitive results that are inconsistent with the actions of rational profit-maximizing players. The use of one-stage oligopoly models for market structure analysis should then be limited to the theoretically well-understood cases of Cournot competition and perfect competition.

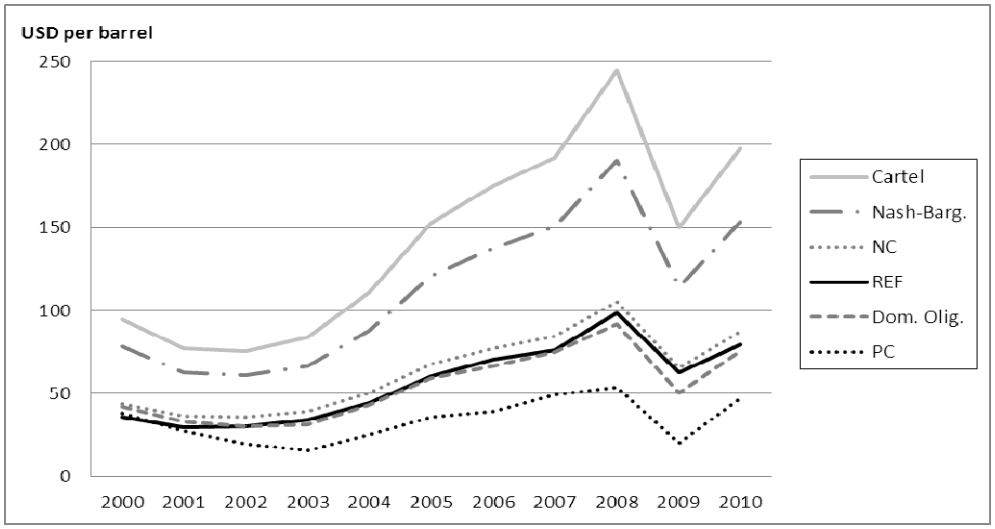
Huppmann and Holz (2012) propose a model for the global crude oil market; their work, however, includes a detailed spatial disaggregation of crude oil trade. It is hence less detailed with respect to the game-theoretic structure. Our work, in contrast, includes a more sophisticated representation of market power following Haftendorn (2012). In addition, recognizing that OPEC is not a typical cartel, we also implement a Nash-bargaining game.

In order to properly model a dominant oligopoly and a competitive fringe we use a two-stage approach based on the Stackelberg game, so that the dominant oligopoly takes fully into account the reaction of the fringe to its actions. We implement different market structures for the dominant oligopoly: a Cournot oligopoly, a cartel and Nash-bargaining competition.

The above described models are based on quantity games: the decision variable and the variable the players can influence strategically are the quantities offered to the market. However, it is often argued that the price of crude oil is set by netback pricing, i.e., the mark-up demanded by oil companies. We hence investigate the effect of using the netback directly as a strategic variable. This mark-up up can be interpreted as a tax-rate and such models are based on the seminal work by Kolstad and Wolak (1983) for the US coal market. Such a model may also give a more realistic depiction of the revenue maximization behavior of OPEC members.

We implement the various models in GAMS and solve them numerically for the years 2000 to 2010.

Results



Our preliminary results are shown in the figure above. The dominant oligopoly can behave either as a cartel (Cartel line), compete in a Nash-bargaining way (Nash-Barg. line) or in a Cournot way (Dom. Olig. line). The NC line shows the case where all the players in the market compete in a Nash-Cournot way. The PC line shows the outcome of a perfect competition simulation while the REF line shows the actual market prices from 2000 to 2010.

Conclusions

The results of the simulation of the dominant oligopoly competing in a Cournot manner are consistently the closest to the actual market outcomes except after 2008. We reject the hypothesis that OPEC acts as a cartel. The higher reference prices after 2008 could be explained by speculation.
The model using the netback as a strategic variable proves to be an interesting research angle but needs to be further specified by differentiating the countries inside the OPEC cartel for example between Saudi Arabia and the other OPEC members. Otherwise the results prove to be similar to the quantity results discussed above.

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